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CHANGES IN GRADE AND VOLUME OF CENTRAL CALIFORNIA WHITE FIR LUMBER DURING DRYING AND SURFACING

by

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ABSTRACT

Lumber from 20 white fir trees, totaling over 43,000 board feet, was carefully graded in the rough green, rough dry, and surfaced dry condition. Grade and volume changes occurring after each stage in processing were recorded and analyzed.

Results indicate a considerable loss of grade during drying and surfacing with 43 percent of the green study lumber degrading one or more grades. A total of 55 percent of the rough green study lumber remained on grade or was upgraded after drying and surfacing; 2 percent was lost as trim or cull. Select grades generally degraded more than the Shop and Dimension grades during drying and again during surfacing.

Losses after surfacing accounted for a greater part of the decrease, dropping the overrun from 25.1 percent in the rough green to 24.6 percent in the rough dry to 22.6 percent in the surfaced dry condition.

Keywords: Lumber seasoning, wood quality, lumber, white fir.

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INTRODUCTION

The western true firs (*Abies* sp.) are becoming progressively more important as a source of raw material for the wood-using industry. Though they represent only 13 percent of the total commercial softwood sawtimber volume in the West, these species approximate 25 percent of the softwood sawtimber in California. In the central Sierras of California, nearly 50 percent of the sawtimber is made up of red and white fir. In 1967, approximately 2 billion board feet of true fir lumber was produced; of this amount, nearly half was produced in California.

The increasing demand for lumber has placed white fir (*A. concolor* (Gord. & Glend.) Lindl.), once considered an "inferior" species, in a position of being an important source of lumber. This has resulted in an increasing need for up-to-date information on grade recovery for this species. Furthermore, changes in utilization standards, manufacturing, and marketing occurring within the last few years have made it imperative that more recent data on grade and volume change in white fir lumber during processing be available. Information of this type is needed by the Forest Service and other public agencies for timber appraisal and timber quality evaluation, and by lumber industry for evaluating and updating processing procedures.

This report presents data collected during the summer of 1967 in California on the changes in grade and volume after drying and surfacing of white fir lumber. Red fir which is generally included in commercial white fir lumber was not included in this study. These data were part of those collected in a general study designed primarily to investigate some of the more important external-internal relations of wood quality in white fir logs.

The study was performed in cooperation with the University of California Forest Products Laboratory, Richmond, Calif., and the American Forest Products Corporation at Martell, Calif.

PROCEDURE

Twenty white fir trees were selected from a single site in an active logging area in the Eldorado National Forest, Calif. Trees covering as wide a diameter range as could be found in the immediate logging area were selected. Prior to felling, each tree was examined in its natural state; surface characteristics for the first 32 feet were diagramed (Jackson et al. 1963), and other important details of the tree and surrounding area were noted and recorded. Additional diagraming instructions are given in a report by Pong and Jackson (1971). Each tree was numbered, then was felled and bucked into lengths in

accordance with the industry practice. Tree and log measurements were recorded (see table 1). Minimum log size taken was 10-foot length, 10-inch d.i.b. (diameter inside bark) at the small end with a net scale of 50 percent of gross scale. Cull logs and logs not meeting minimum size requirements were left in the woods.

Table 1.--*Distribution of size, age, and form class of white fir study trees*

Tree number	D.b.h.	Total height	Age[1/]	Form class	
				16 feet	32 feet
	Inches	*Feet*	*Years*		
1	24.3	100	143	72	63
2	23.8	97	95	76	80
3	46.2	142	141	74	69
4	46.4	182	150	79	67
5	18.6	99	145	72	69
6	21.2	110	145	74	70
7	21.5	104	83	78	71
8	17.2	94	79	87	83
9	28.0	137	147	74	70
10	29.8	139	139	80	78
11	37.4	158	144	80	80
12	38.1	160	143	74	67
13	24.9	115	98	68	65
14	20.7	92	94	79	73
15	20.1	88	130	69	56
16	32.4	156	149	75	77
17	46.9	175	169	73	69
18	39.2	165	176	69	63
19	40.7	168	146	74	72
20	37.1	129	109	72	65

[1/] At stump height.

In the mill yard, study logs were graded using a system of three grades (Wise and May 1958): Select (grade 1), Shop (grade 2), and Common (grade 3).[1/] The Common grade of logs was most numerous. Log lengths varied from 10 to 20 feet (table 2) with greatest concentration in the 16-foot length. Log diameters at the small end varied from 10 to 39 inches (table 3). A total of 112 logs

[1/] *Logs in the Common grade include both high and low Commons (Wise and May 1958).*

Table 2.--*Distribution of study logs by length and log grade*

Log length (feet)	Number of logs by log grades[1/]			
	1	2	3[2/]	All grades
10	0	0	10	10
12	0	0	9	9
14	0	1	3	4
16	8	11	67	86
18	0	0	2	2
20	0	0	1	1
Total	8	12	92	112

[1/] See Wise and May 1958.

[2/] Logs in this grade include high and low Commons (Wise and May 1958).

Table 3.--*Distribution of study logs by diameter class and log grade*

Diameter inside bark (inches)	Number of logs by log grades[1/]			
	1	2	3[2/]	All grades
9.6 - 12.5	0	0	15	15
12.6 - 15.5	0	3	15	18
15.6 - 18.5	0	3	15	18
18.6 - 21.5	0	0	9	9
21.6 - 24.5	1	1	15	17
24.6 - 27.5	1	1	11	13
27.6 - 30.5	3	2	4	9
30.6 - 33.5	2	0	4	6
33.6 - 36.5	0	2	4	6
36.6 - 39.5	1	0	0	1
Total	8	12	92	112

[1/] See Wise and May 1958.

[2/] Logs in this grade include high and low Commons (Wise and May 1958).

from the 20 study trees were sawn into lumber. Not included in this study were five mill-length study logs which were lost in transit from the field to the mill.

Each log was sawed with the intent of recovering the optimum value through manufacture of usual lumber items. Sawing practices during the study period conformed to general industry practice in the west-side Sierras and were geared to produce Select, Shop, Common, and Dimension lumber. All lumber was sawed to meet Western Wood Products Association (WWPA) specifications.

Boards from each log were identified by color coding and marking with an assigned mill log number and stamped consecutive board numbers. A WWPA grader using purple keel marked all lumber on the green chain by grade. In this grading and all subsequent grading, boards were graded "as is" without regard to an anticipated grade. Trimming of lumber at any stage in the study was restricted to pencil trimming only; actual trimming of the study lumber was not done until after it was surfaced and graded.

It is the practice of the company to segregate the green lumber into three drying sorts (sap, corky, and sinker) (Smith and Dittman 1960) for each of four thicknesses (4/4, 5/4, 6/4, and 7/4). A fourth sort (4- by 4-inch dimension) called "No. 4" or dunnage was cut from the shaky cores. Normally there is no green grading of the white fir lumber by the mill. Study lumber was not tallied in the green condition except for the "No. 4" and all of the 4/4 lumber; these were hand tallied by board number, mill log number, green grade, width, length, and thickness. Since there was to be no further processing of the dunnage and the 4/4 lumber, we assumed the green grade of this lumber would have held true if dried and later if surfaced. The remainder of the lumber was tallied after kiln drying.

After sorting on the green chain, all lumber to be kiln dried was stickered into kiln packages of one drying sort. Since the volume of study material in each sort was not sufficient to fully charge a kiln, packages of green, nonstudy white fir lumber of the same drying sorts were loaded into the kilns for drying with the study lumber.

Modern, single track, internal fan, cross-circulation kilns were used to dry the study lumber. Since there were basically three drying sorts (sap, corky, and sinker), three different kiln charges and three different kiln schedules were used. These time-temperature schedules are listed in table 4. Each schedule gave a 5- to 10-percent redry and an average moisture content of 15 to 16 percent with a maximum moisture content of 19 percent.

After the drying, the same grader that evaluated the lumber in the green condition regraded and marked the lumber on the dry sorting chain.

Table 4.--*Dry kiln schedules for sap, sinker, and corky white fir lumber, American Forest Products Corporation, Martell, California*

Time (hours)	Temperatures		
	Dry bulb	Wet Bulb	Wet bulb depression
	Degrees F.		
Sap:			
0-36	160	140	20
37-76	170	140	30
77-100	180	140	40
101-106 conditioning			
Total time: 106 hours			
Sinker:			
0-24	160	140	20
25-60	170	140	30
61-168	180	140	40
169-174 conditioning			
Total time: 174 hours			
Corky:			
0-24	160	140	20
25-54	170	140	30
55-60 conditioning			
Total time: 60 hours			

The rough-dry grade marks were made with red color keel. The grade mark and any pencil trim were made on the same end and side on which the rough-green grade mark and trim appeared. The lumber was then photographed board by board, with color film (Pong et al. 1970). A hand tally of each board was also made. Here the green and dry grades were recorded along with any green and dry pencil trimming, board and log numbers, length, width, and thickness. From the combination of a photo tally and a hand tally, accurate records of the lumber in the rough green and rough dry condition were obtained. Rough dry boards were pulled on the dry sorting chain according to grade, width, and thickness.

Rough dry dimension lumber was planed S4S; Selects, Shops, and Commons were planed S2S. The procedure for tallying at the planer was as follows: boards entering the planer were recorded in turn on data sheets by

the consecutive stamped numbers which were originally affixed to the boards on the green chain. As each board left the planer, it was marked by grade, pencil trimmed, and a consecutive number was written on its surface. This number coincided with the number of entries that were made on the data sheets as boards were fed into the planer. Each surfaced board was then photographed with color film (Pong et al. 1970). The same man that graded the rough green and rough dry lumber regraded the surfaced lumber.

DATA PROCESSING

Hand tallied data for rough green and rough dry boards were edited and corrected using the photo tally made on the dry sort chain. The hand tally of consecutive numbers at the infeed of the planer were matched and corrected using the tallies for rough green and rough dry boards. The board data for the surfaced dry lumber were then transferred from the photo tally of surfaced lumber to the tally sheets on which the consecutive stamped numbers, as recorded at the infeed of the planer, had been entered. Keypunch operators transferred the data for each phase of the study from the tally sheets to punch cards. A detailed matching was then made of all boards from rough green to rough dry to surfaced dry for each log. The cards were then analyzed by automatic data processing (ADP) for changes in grade and volume for each stage of processing. Other ADP analyses were made on lumber recovery for different log grades, grades of lumber from different log grades, and overrun percentages. In these analyses, Common grades of lumber, i.e., 2 Common, 3 Common, and 4 Common, were combined with the dimension grades of Standard, Utility, and Economy, respectively (Anonymous 1968).

RESULTS – GRADE AND VOLUME CHANGE

Rough Green to Rough Dry

The volume of lumber that remained on grade during drying ranged from 0 to 88.5 percent of the volumes of green lumber in the several individual grades (table 5). Grade retention was highest in the 1 Shop grade. The Select grades (B Select to Molding) were downgraded consistently more than the Shop grades (3 Clear to 3 Shop) except for 3 Clear, or the Dimension grades (Construction to Economy).

About 12 percent of the volume of green lumber graded out as Selects in the rough dry condition, 13 percent as Shop, and 72 percent as Dimension. Approximately 6 percent of the total volume of green lumber was regraded to a higher grade after drying, 77 percent held true to grade, and 17 percent was

downgraded. Dunnage made up 2.5 percent of the lumber volume. As noted previously, this material was not dried or surfaced. Less than 1 percent of the total volume of green lumber was lost through pencil trimming in the rough dry condition.

Because this study did not record reasons for changes in grade, it would be presumptuous to attribute all changes in grade to drying alone. Some of the changes, no doubt, resulted from other causes, i.e., natural defects, mismanufacturing, and evaluation by the grader (Pong and Smith 1962). The fact that the initial conditions for the kiln schedules (see table 4) used in this study are probably better suited for drying dimension lumber and lower grade white fir suggests that they may have been too severe for the upper grades of lumber. Milder schedules (Rasmussen 1961) would have undoubtedly minimized drying defects in these grades.

Rough Dry to Surface Dry

The volume of rough dry lumber that remained on grade during surfacing ranged from 0 to 77.7 percent in the several individual grades (table 6). The Economy grade had the highest percentage. This is to be expected since the characteristics permitted under the grading rules for this lumber grade are much less limiting than for other grades. The next highest percentage remaining on grade was for Molding which registered 59.7 percent. As in the case of drying, the Select grades generally degraded more during surfacing than either the Shop or the Dimension grades. One notable exception was the high downgrading of 1 Shop which, as noted in the previous section, had the highest grade retention after drying.

Of the total volume of rough dry lumber, about 7 percent graded out as Selects after surfacing, 13 percent as Shop, and 75 percent as Dimension. Approximately 9 percent of the rough dry lumber was upgraded after surfacing, 52 percent retained the same grade, and 37 percent was downgraded. Nearly 2 percent of the volume of rough dry lumber was lost during the surfacing as the result of trimming. The first three Select grades (B, C, and D Selects) actually gained instead of losing volume during surfacing. Noting further the very high percentages of downgrading for these grades, one could conclude that trimming alone would not have changed the downgrading pattern of the boards in these grades--some more important downgrading factor or factors, unaffected by trimming, was influencing it.

Rough Green to Surfaced Dry

The volume of rough green lumber that remained on grade after surfacing ranged from 0 to 82.1 percent for the various individual grades (table 7).

The lowest grade, Economy, had the highest grade retention followed by Construction with a 51.3-percent retention. Select grades generally were downgraded considerably more than the Shop and Dimension grades; a high amount of downgrading was recorded for 1 Shop. Most of the downgrading of 1 Shop was recorded during the surfacing of the rough dry material (see table 6); a small amount was recorded after the green lumber was dried (see table 5).

About 7 percent of the volume of rough green lumber graded out as surfaced dry Selects, 13 percent as Shop, and 75 percent as Dimension. More than 8.5 percent of the green lumber was upgraded, 46.8 remained unchanged, and 42.5 was downgraded in the surfaced dry condition. A 2.1-percent loss in volume from rough green to surfaced dry was recorded.

The unchanged volume percentages in table 7 can be compared with those presented in table 5 since both are based on green lumber volume. As expected, the unchanged volume percent for various grades of rough green lumber in the surfaced dry condition (table 7) showed a marked drop when compared with recorded values in the rough dry condition (table 5). Most of this change was recorded as an increase in the volume of downgraded lumber in each of the individual grades. There was also a noticeable increase in loss of volume for each individual grade; how much was caused by surfacing alone cannot be ascertained. It can be assumed, however, that not all of the increase in downgrading for the individual grades is the result of surfacing alone. Cause of this downgrading no doubt was already present in the rough dry lumber before surfacing and went undetected until after surfacing. Thus, surfacing in reality gave the grader a better specimen to examine and to evaluate and eliminated much of the guesswork which goes into grading rough boards.

As previously noted, the upper grades of lumber had less volume remaining on grade than the lower grades of lumber after each step of processing. This is to be expected because of more stringent grading rules for upper grades of lumber. Furthermore, because appraising upper grades is more difficult (Pong and Smith 1962), the potential for errors in evaluating these grades is probably greater than in the lower grades. In the lower grades, some inaccuracies in evaluating grading defects after each step in processing may have little effect on the lumber grade.

A comparison of the figures in tables 6 and 7 for lumber retaining its grade gives some indication of the effectiveness of grading green lumber as opposed to grading dry lumber in segregating the various lumber grades prior to surfacing. Table 7 shows the percentage of lumber in the various grades of green lumber which would have retained the same grade after drying and surfacing. In table 6, the percentages of volume unchanged for the individual grades of rough dry lumber represent the lumber retaining the same grade

Table 5.--Volume of white fir lumber recovered

Grade of rough green lumber	Volume of rough green lumber	Grades of lumber							
		B Select	C Select	D Select	Molding	3 Clear	1 Shop	2 Shop	3 Shop
	Bd. ft.	*Percent*[1/]							
B Select	753	50.9	24.3	2.7	17.2	0	0	0	0
C Select	855	1.9	32.0	31.4	14.9	1.9	0	6.2	0
D Select	2,619	.7	6.6	54.1	8.9	.2	2.0	11.6	0
Molding	2,100	0	0	5.6	66.4	0	.9	13.2	.7
3 Clear	29	0	0	36.4	0	0	0	0	0
1 Shop	595	0	0	0	0	0	88.5	11.8	0
2 Shop	4,588	0	.7	.9	1.5	0	.3	80.8	4.1
3 Shop	161	0	0	0	0	0	0	0	82.0
Construction	16,300	0	0	.5	0	0	0	.4	0
Standard	6,108	0	0	.2	0	0	0	1.4	.4
Utility	5,399	0	.2	.1	.1	0	0	.8	0
Economy	2,510	0	0	0	0	0	0	1.0	1.0
Cull	0	--	--	--	--	--	--	--	--
Dunnage	1,072	--	--	--	--	--	--	--	--
Average	43,089	1.0	1.6	4.6	4.5	0	1.4	10.8	.9

[1/] Percentages are based on the accumulation and/or differences in board volumes within each of the categories shown and not on the accumulation or differences of individual

Table 6.--Volume of white fir lumber recovered from

Grade of rough dry lumber	Volume of rough dry lumber	Grades of lumber							
		B Select	C Select	D Select	Molding	3 Clear	1 Shop	2 Shop	3 Shop
	Bd. ft.	*Percent*[1/]							
B Select	417	36.8	16.5	21.8	14.8	0	2.9	1.4	0
C Select	672	2.5	9.9	31.6	14.4	0	3.6	14.1	7.1
D Select	1,977	0	5.2	15.5	8.6	0	6.2	21.8	8.5
Molding	1,959	0	0	12.5	59.7	0	8.6	12.2	1.1
3 Clear	21	0	0	75.0	0	0	0	0	0
1 Shop	613	0	0	0	0	0	13.2	64.8	9.8
2 Shop	4,633	0	0	.6	2.8	0	2.2	44.7	19.2
3 Shop	382	0	0	0	5.6	0	0	10.0	54.1
Construction	14,818	0	0	0	0	0	0	.6	1.2
Standard	7,842	0	0	.1	0	0	0	.3	.9
Utility	5,873	0	0	0	0	0	0	1.0	1.3
Economy	2,615	0	0	0	0	0	0	.4	2.7
Cull	11	0	0	0	0	0	0	0	0
Dunnage	1,072	--	--	--	--	--	--	--	--
Average	42,905	.4	.6	2.1	3.8	0	1.2	8.1	4.1

[1/] Percentages are based on the accumulation and/or differences in board volumes within each of the categories shown and not on the accumulation or differences of individual

from various grades of rough green lumber after drying

Grades of lumber (continued)						Unchanged	Down-graded	Upgraded	Volume loss
Construction	Standard	Utility	Economy	Cull	Dunnage				
Percent[1]									
4.3	0	0	0	0	--	50.9	48.5	0	0.7
6.2	3.7	.4	0	0	--	32.0	64.7	1.9	1.4
9.8	3.6	1.9	0	0	--	54.1	38.1	7.3	.5
2.0	4.0	4.4	2.3	0	--	66.4	27.5	5.6	.5
54.5	0	0	0	0	--	0	54.5	36.4	9.1
0	0	0	0	0	--	88.5	11.8	0	+.3
2.6	3.1	6.0	0	0	--	80.8	15.8	3.4	0
0	0	9.9	3.7	0	--	82.0	13.7	0	4.3
82.6	13.7	2.5	0	0	--	82.6	16.2	1.0	.3
10.9	74.0	11.7	.8	0	--	74.0	12.5	12.8	.7
2.9	13.2	74.4	7.5	0	--	74.4	7.5	17.3	.9
.8	1.2	11.8	83.6	.4	--	83.6	.4	15.8	.2
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	100.0	[2]100.0	--	--	--
34.4	18.2	13.6	6.1	0	2.5	76.7	16.6	6.4	.4

percentages. This may result in some minor differences in percentage totals.

[2] Not dried or surfaced.

various grades of rough dry lumber after surfacing

Grades of lumber (continued)						Unchanged	Down-graded	Upgraded	Volume loss
Construction	Standard	Utility	Economy	Cull	Dunnage				
Percent[1]									
0	2.2	6.1	1.3	0	-	36.8	67.0	0	+3.8
9.7	2.0	6.9	0	0	--	9.9	89.5	2.5	+1.8
13.5	11.1	6.4	4.2	0	--	15.5	80.3	5.2	+1.0
.4	2.9	.3	2.3	0	--	59.7	27.7	12.5	0
0	0	0	25.0	0	--	0	25.0	75.0	0
0	0	0	3.9	0	--	13.2	78.5	0	8.3
5.4	4.8	4.1	3.8	0	--	44.7	37.4	5.6	12.3
0	0	0	21.0	0	--	54.1	21.0	15.6	9.3
57.8	31.0	7.5	1.8	0	--	57.8	40.3	1.8	.2
13.9	50.2	29.8	4.7	0	--	50.2	34.5	15.1	.2
2.3	18.3	45.1	31.5	0	--	45.1	31.5	22.9	.5
0	1.4	14.6	77.7	1.0	--	77.7	1.0	19.1	2.2
0	0	0	75.0	0	--	0	0	75.0	25.0
--	--	--	--	--	100.0	[2]100.0	--	--	--
24.2	23.7	16.0	11.5	.1	2.5	52.0	37.0	9.3	1.6

percentages. This may result in some minor differences in percentage totals.

[2] Not dried or surfaced.

Table 7.--Volume of white fir lumber recovered from various

Grade of rough green lumber	Volume of rough green lumber	B Select	C Select	D Select	Molding	3 Clear	1 Shop	2 Shop	3 Shop
	Bd. ft.	*Percent*[1/]							
B Select	753	22.6	7.8	20.7	23.5	0	8.5	4.6	0
C Select	855	0	7.4	26.0	12.0	0	17.6	11.9	2.5
D Select	2,619	0	4.4	13.1	12.6	0	3.5	23.3	6.7
Molding	2,100	0	0	7.4	45.1	0	2.7	14.2	7.6
3 Clear	29	0	0	0	0	0	0	0	0
1 Shop	595	0	0	0	1.3	0	7.4	55.8	16.6
2 Shop	4,588	0	0	.6	1.7	0	2.2	39.0	19.0
3 Shop	161	0	0	0	4.7	0	0	5.0	46.9
Construction	16,300	0	0	0	0	0	0	1.1	1.0
Standard	6,108	0	0	0	0	0	0	1.1	1.3
Utility	5,399	0	0	0	0	0	0	.7	1.0
Economy	2,510	0	0	0	0	0	0	.4	3.2
Cull	0	--	--	--	--	--	--	--	--
Dunnage	1,072	--	--	--	--	--	--	--	--
Average	43,089	.4	.6	2.1	3.8	0	1.2	8.0	4.1

[1/] Percentages are based on the accumulation and/or differences in board volumes within each of the categories shown and not on the accumulation or differences of individual

after surfacing. These results indicate that, in general, grading of rough green lumber is less effective than grading of rough dry lumber in segregating lumber for surfacing. An obvious advantage of grading after drying is the appearance of drying defects which grading of rough green lumber alone cannot fully foresee. The higher figures in table 6 for retention of grade were probably the direct result of this. It should be noted, however, that the two lowest lumber grades, Utility and Economy, did not follow this pattern. In both of these grades, grade retention was less than that recorded in table 7. The advantages of grading of dry lumber over grading of green in segregating lumber for surfacing in these two grades appear to be minimal.

On the average, grading of dry lumber resulted in 52-percent retention of grade after surfacing, with 37 percent downgraded, and 9.3 percent upgraded (table 6). The same figures for grading of green lumber are, respectively, 46.8, 42.5, and 8.6 percent (table 7).

LUMBER GRADE RECOVERY

Table 8 presents the percentages of lumber grade recovery by log grade for study lumber in the rough green, rough dry, and surfaced dry condition.

grades of rough green lumber after drying and surfacing

Grades of lumber (continued)						Unchanged	Downgraded	Upgraded	Volume loss
Construction	Standard	Utility	Economy	Cull	Dunnage				
Percent[1/]									
9.1	1.2	3.4	0.7	0	--	22.6	79.6	0	+2.1
3.7	13.4	3.0	1.9	0	--	7.4	91.9	0	.7
15.0	10.1	7.7	2.2	0	--	13.1	81.3	4.4	1.3
3.3	9.7	2.8	4.5	0	--	45.1	44.8	7.4	2.7
90.9	0	0	0	0	--	0	90.9	0	9.1
4.7	0	0	4.0	0	--	7.4	81.2	1.3	10.2
6.2	7.5	6.5	6.6	0	--	39.0	45.8	4.5	10.6
0	0	9.9	24.8	0	--	46.9	34.8	9.6	8.7
51.3	33.3	10.2	2.5	0	--	51.3	46.0	2.1	.6
14.7	43.9	28.6	9.5	.2	--	43.9	38.2	17.0	.9
3.9	20.7	47.1	25.1	0	--	47.1	25.1	26.3	1.5
0	.2	11.7	82.1	.6	--	82.1	.6	15.5	1.8
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	100.0	[2/] 100.0	--	--	--
24.1	23.6	15.9	11.5	.1	2.5	46.8	42.5	8.6	2.1

percentages. This may result in some minor differences in percentage totals.

[2/] Not dried or surfaced.

Percentage of lumber recovered in the rough green, rough dry, and surfaced dry condition in each lumber grade for all log grades combined is also presented.

As expected, the higher grade logs (grades 1 and 2) produced more lumber in the upper grades (Selects and Shops) than did lower grade logs (grade 3), which produced more Dimension grades of lumber.

A comparison of the lumber recovery between grades 1 and 2 logs indicates that the recovery from these log grades is essentially the same in the rough green and rough dry stages. Notable exceptions are the percentages of recovery for 1 Shop (rough green) and 3 Shop, and the Economy grade. The recovery of the Economy grade was exceptionally high from the grade 2 logs in both the rough green and rough dry as well as in the surfaced dry condition. No doubt this high percentage of recovery is related to the low recovery of dunnage (0.8 percent) in the grade 2 logs; dunnage recovery in grades 1 and 3 logs was, respectively, 3.3 and 2.7 percent.

In the surfaced dry condition, percentages of lumber recovery for grades 1 and 2 logs differed most noticeably in the Select, 3 Shop, and the

Table 8.--Percentages[1] of lumber grade recovery by log grade for lumber in the rough green, rough dry, and surfaced dry condition

Log grade[2]	Grades of lumber													
	B Select	C Select	D Select	Molding	3 Clear	1 Shop	2 Shop	3 Shop	Construction	Standard	Utility	Economy	Cull	Dunnage
Rough green:														
1	4.5	4.8	18.1	11.9	0.3	1.3	9.2	1.6	23.8	7.8	11.0	2.4	0	3.3
2	5.4	3.9	15.2	8.9	.2	.2	13.1	.1	24.7	7.1	10.1	10.3	0	.8
3[3]	.6	1.1	2.2	2.8	0	1.6	10.5	.2	42.8	16.6	13.3	5.6	0	2.7
All	1.7	2.0	6.1	4.9	.1	1.4	10.6	.4	37.8	14.2	12.5	5.8	0	2.5
Rough dry:														
1	2.3	4.4	14.9	11.9	0	.7	12.5	3.4	22.5	12.6	9.4	2.1	0	3.3
2	3.4	5.0	11.9	9.4	0	1.1	13.4	.5	23.9	10.2	10.2	10.2	0	.8
3[3]	.3	.4	1.4	2.3	.1	1.6	10.0	.5	38.6	20.7	15.1	6.1	.1	2.7
All	1.0	1.6	4.6	4.6	(4)	1.4	10.8	.9	34.5	18.3	13.7	6.1	(4)	2.5
Surfaced dry:														
1	0.1	.8	6.4	13.4	0	2.2	11.5	8.7	20.7	15.0	9.5	8.4	0	3.3
2	1.9	2.1	4.8	6.8	0	2.6	11.7	4.6	19.6	15.2	14.9	15.0	0	.8
3[3]	.2	.2	.9	1.6	0	.8	7.0	3.3	26.3	27.5	17.8	11.7	.1	2.7
All	.4	.6	2.1	3.9	0	1.2	8.2	4.2	24.6	24.2	16.3	11.7	.1	2.5

[1] Percentages may not total correctly because of rounding.

[2] See Wise and May 1958.

[3] Logs in this grade include high and low Commons (Wise and May 1958).

[4] Less than 0.05 percent.

lower Dimension grades. Recovery of Selects (B, C, D Selects and Molding) was 20.7 percent for grade 1 logs and 15.6 percent for grade 2. In grade 1 logs, more than half of the recovery of Selects was in Molding, and in grade 2 logs, less than half was in Molding. The recovery of 3 Shop from grade 2 logs was about half of that recovered from grade 1 logs. In grade 2 logs, the lower grades of Dimension (Utility and Economy) made up nearly 30 percent of the volume recovered; in grade 1, almost 18 percent.

Recovery of surfaced dry Selects from grade 3 logs was 2.9 percent; Shop grades of lumber totaled 11.1 percent, and Dimension, 83.3. Comparable figures for grade 1 logs are: Selects, 20.7 percent; Shops, 22.4; Dimension, 53.6. For grade 2 logs, these figures are: Selects, 15.6 percent; Shops, 18.9; and Dimension, 64.7. For all logs combined, Selects totaled 7 percent; Shops, 13.6 percent; and Dimension, 76.8 percent of the recovery of surfaced dry lumber.

Log Defect Percent, Lumber Tally, and Overrun

Table 9 summarizes the log scale and percent of defect in study logs for each of the log grades. Tallies of recovery of rough green, rough dry, and surfaced dry lumber are also presented. For grade 1 logs, the percent of defect averaged 4.5 percent; grade 2, 4.7 percent; and grade 3, 5.3 percent. For individual logs, percentages of defect registered much higher (table 10). The average deduction for defect for all logs was 5.1 percent of the gross log scale.

Losses for each grade of log due to processing increased with each step in the processing (see table 9). These losses, however, were not substantially different for any given step in processing among various grades of logs--losses from rough green to rough dry were 0.2 to 0.5 percent and from rough dry to surfaced dry, 1.3 to 1.8 percent. Average for all logs combined was: rough green to rough dry, 0.4 percent; and rough dry to surfaced dry, 1.6 percent.

Losses resulting from processing are also reflected in the change in the overrun (see table 9). For each log grade, a decrease occurred in the overrun with each processing step. Similar results can be seen for the overrun for all logs combined.

Tallies of the rough green, the rough dry, and the surfaced dry lumber showed that overrun values increased with decreasing log grade (table 9). A consistent overrun differential between log grades 1 and 2 of approximately

Table 9.--*Summary of log scale, defect, lumber recovery, losses, and overrun by log grades*

Log grade[1]	Number of logs	Log scale		Defect[2]	Lumber recovery			Losses		Overrun[3]		
		Gross	Net		Rough green	Rough dry	Surfaced dry	Rough green to rough dry	Rough dry to surface dry	Rough green	Rough dry	Surfaced dry
		Board feet		*Percent*	*Board feet*			*Percent*				
1	8	5,280	5,040	4.5	5,870	5,857	5,752	0.2	1.8	16.5	16.2	14.1
2	12	4,870	4,640	4.7	5,708	5,654	5,580	.5	1.3	23.0	21.9	20.3
3[4]	92	26,140	24,760	5.3	31,511	31,394	30,888	.4	1.6	27.3	26.8	24.7
Total	112	36,290	34,440	5.1	43,089	42,905	42,220	.4	1.6	25.1	24.6	22.6

[1] See Wise and May 1958.

[2] Percent gross log scale.

[3] Percent net log scale.

[4] Logs in this grade include high and low Commons (Wise and May 1958).

Table 10.--*Overrun and losses for rough green, rough dry, and surfaced dry lumber, and log scale defect for various study-log diameter classes*

Diameter class[1] (inches)	Number of logs	Overrun[2]			Defect[3]	Losses	
		Rough green	Rough dry	Surfaced dry		Rough green to rough dry	Rough dry to surfaced dry
		Percent					
10	9	64	66	66	7.7	+1.4	0.2
11	1	66	66	61	0	0	2.7
12	5	42	41	49	0	.5	+5.8
13	7	42	40	40	1.5	1.4	.4
14	5	55	54	51	4.6	1.0	1.9
15	6	34	33	34	1.2	.8	+.6
16	8	35	32	33	3.1	2.2	+.9
17	7	34	35	33	3.9	+.8	1.4
18	3	28	27	28	0	.8	+.5
19	4	51	50	46	2.2	.8	2.2
20	4	26	25	25	2.7	.8	+.1
21	1	26	28	27	0	+1.9	.8
22	7	33	33	33	1.4	.3	0
23	5	27	27	27	4.8	.2	.2
24	5	32	32	31	4.7	.2	1.0
25	4	21	20	18	.6	1.1	.9
26	3	13	12	11	3.8	.9	1.0
27	6	21	21	19	5.5	.1	2.2
28	3	27	26	23	9.8	.5	2.6
29	2	17	17	11	.8	+.3	5.7
30	4	17	17	16	4.9	.3	.3
31	2	13	13	06	16.1	+.5	6.8
32	3	22	21	17	6.3	.3	3.3
33	1	07	07	05	14.1	.1	1.8
34	2	17	17	10	5.0	.1	6.0
35	3	25	24	19	9.9	.3	4.4
36	1	12	09	11	4.3	3.2	+2.3
37	0	--	--	--	--	--	--
38	0	--	--	--	--	--	--
39	1	07	07	04	6.2	.6	2.3
All classes	112	25	25	23	5.1	.4	1.6

[1] Diameter inside bark class.

[2] Percent net log scale.

[3] Percent gross log scale.

6 percent, between grades 2 and 3 of more than 4 percent, and over 10 percent between grades 1 and 3, was recorded in the tallies regardless of the stage of processing.

The higher overrun values recorded for the lower grades of logs (table 9) are, no doubt, due in part to the greater occurrence of smaller diameters in these logs (see table 3) which, because of the Scribner rule, results in a greater overrun. Percent of overrun by 1-inch diameter classes for the study logs is presented in table 10. From this table, it can be seen that overrun for the smaller logs is much higher than for the larger logs.

Based on the individual tallies for study logs, curves of rough green, rough dry, and surfaced dry overrun versus log diameter were calculated by least squares and plotted. These curves are presented in figure 1; each is highly significant at the 1-percent level for 109 degrees of freedom. The curve for rough green overrun and the curve based on the tally of rough dry lumber are similar for the range of log diameters included in this study. The curve for surfaced dry overrun, however, though similar for smaller logs, showed an increasing deviation from the curves for rough green and rough dry lumber with increasing log diameter. This deviation is significant and is related to the loss of volume which occurred during the drying and surfacing of the study lumber; losses from drying averaged 0.4 percent and from surfacing, 1.6 percent (tables 5 and 6). Overrun decreased from 25.1 percent in the rough green condition to 24.6 percent in the rough dry to 22.6 percent in the surfaced dry condition (table 9).

Comparison of the figures for losses in table 10 shows that the losses for the rough green to rough dry stage were much less than those associated with surfacing. Furthermore, a trend was evident that the losses associated with surfacing increased with increasing log diameter. No such trend was evident with drying.

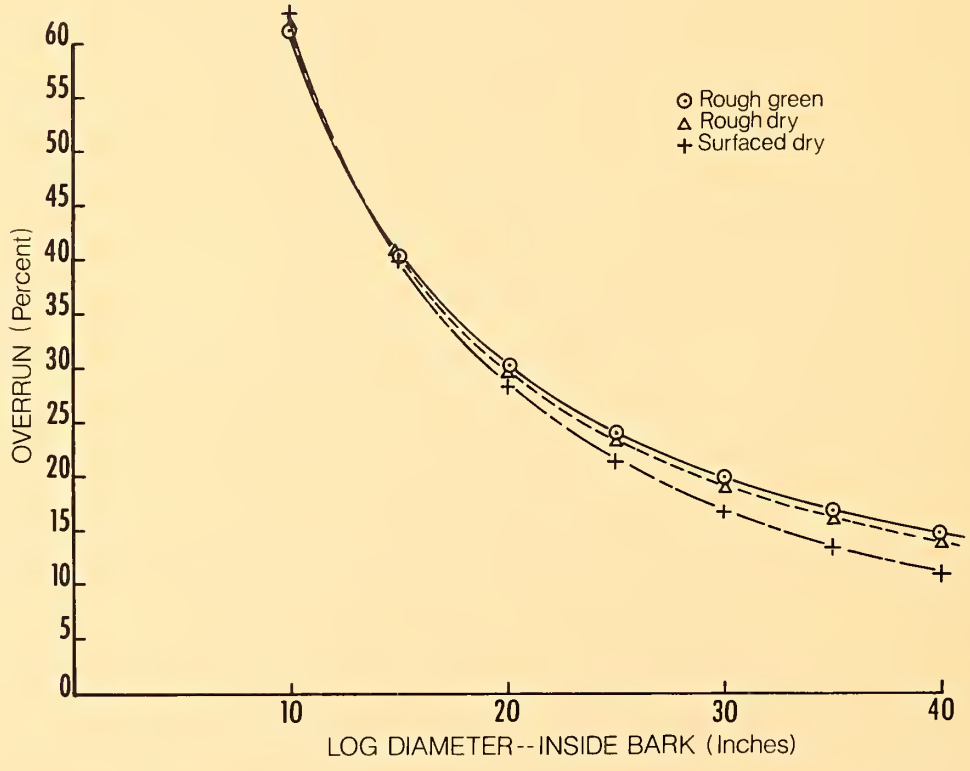

Figure 1.--*Percent overrun vs. log diameter for white fir at different stages of processing.*

CONCLUSIONS

It should be emphasized that the results of this study apply only to the sample tested. To extrapolate these results to white fir in general is dependent on how representative the sample is of white fir. It may be useful, however, to draw from the data certain conclusions regarding grade and volume changes in white fir lumber during processing.

This study indicates a considerable loss of grade during the processing of white fir lumber. Of the 43,000 board feet of green lumber processed in this study, 42.5 percent was downgraded one or more grades during drying and surfacing, 46.8 percent remained on grade, 8.6 percent was upgraded, and 2.1 percent was lost as trim or cull. In general, the Selects were downgraded more than either the Shop or Dimension grades during drying and again during surfacing.

Grading of green lumber was found to be less effective than grading of dry lumber in segregating lumber for surfacing. Grading of dry lumber resulted in approximately 5 percent higher retention of grade and 5 percent less downgrading in the final surfaced volume.

As expected, higher grade logs (grades 1 and 2) produced more upper grades of lumber (Selects and Shops) than the lower grade logs (grade 3) which produced more Dimension grades of lumber.

Losses in lumber tally for each grade of log increased with each step in processing, averaging 0.4 percent during drying and 1.6 percent during surfacing. For any given step in processing, these losses were not substantially different among the various grades of logs.

Overrun decreased with each step in processing, reflecting the processing losses that resulted after drying and surfacing of the lumber. Losses from surfacing accounted for a greater part of the decrease, causing a drop in overrun from approximately 25 percent in the rough green and rough dry conditions to less than 23 percent in the surfaced dry condition.

Increases in overrun with decreasing grades of log were tallied for the rough green, rough dry, and surfaced dry lumber. A preponderance of smaller diameters in the lower grades of logs appears to account for the higher overrun from these logs. A 10-percent overrun differential between extremes in grades of logs exists.

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